

Claims

1. Apparatus for rendering animated image data in real time, comprising:

central processing means,

5 data storage means,

graphical processing means, and

texture storage means, wherein

said data storage means stores data, including scene data, that defines a plurality of sequentially displayable scenes, each of which is rendered as an image sequence in real time;

data for each of said scenes includes a texture for the respective scene, that requires transfer to said texture storage means in advance of said scene being rendered;

said central processing means and said graphical processing means are configured to perform operations to render said scenes, without a pause between scenes, said operations being under control of said central processing means, which is configurable to execute instructions for performing the steps of:

(a) rendering the next frame of the current scene;

20 (b) estimating a bandwidth availability for texture transfer that is unlikely to interfere with the real-time rendering of the current scene;

(c) identifying the amount of data in a texture required for rendering a next scene;

(d) splitting said required texture into texture portions that satisfy said bandwidth availability; and

25 (e) transferring one of said texture portion from said data storage means to said texture storage means.

2. Apparatus according to claim 1, wherein said estimating step (b) includes steps of:

(b1) measuring a processing availability with reference to a due time for a frame in a regularly updated frame sequence;

5 (b2) updating an adaptive statistical model with said processing availability; and

(b3) obtaining an availability estimate from said updated adaptive statistical model.

10 3. Apparatus according to claim 1, wherein said splitting step (d) includes splitting said texture along texture pixels.

4. Apparatus according to claim 1, wherein said transferring step (e) is performed by a process of direct memory access.

15 5. Apparatus according to claim 1, wherein said texture storage means includes texture memory management means for deleting textures.

20 6. Apparatus according to claim 1, wherein said central processing means is configured to execute instructions for performing the additional steps of:

(f) selecting a texture for deletion from said texture storage means; and

25 (g) deciding whether to delete said selected texture in response to the time before the next frame is due to be rendered.

7. Apparatus according to claim 1, including image combining means for combining rendered animation images with images from a live video camera.

8. Apparatus according to claim 1, wherein said central processing means is configured to modify a scene animation projection in response to camera position data.

9. Apparatus for rendering animated image data in real time, comprising:

central processing means,
data storage means,
graphical processing means, and
texture storage means, wherein

said data storage means stores data including scene data, that defines a plurality of sequentially displayable scenes, each of which will be rendered as an image sequence in real time;

data for each of said scenes includes a texture for the respective scene and said texture is transferable to said texture storage means in advance of its rendering; and

said central processing means and said graphical processing means are configured to perform operations to render said scenes, without a pause between scenes, and it is necessary to remove textures from said texture storage means in order facilitate texture storage for next scenes; wherein

said operations are under the control of said central processing means, that is configured to execute instructions for performing the steps of:

- (a) rendering the next frame of the current scene;
- (b) identifying a time before the rendering for the next frame begins;
- (c) comparing said time identified at step (b) with the time required to delete a texture from said texture storage means; and
- (d) if it can be completed before the next frame rendering is due to begin, deleting a texture from said texture storage means.

10. Apparatus according to claim 9, wherein said central processing means is configured to execute instructions for performing the additional step of:

- (e) downloading a texture into a portion of said texture storage means that has been emptied by said deleting step (d).

11. A method of rendering animated image data in real time, in a system comprising a central processing means, data storage means, graphical processing means, and texture storage means; wherein

said data storage means stores data including scene data defining a plurality of sequentially displayable scenes;

data for each of said scenes includes a texture for the respective scene, requiring transfer to said texture storage means in advance of the rendering of its respective scene; and

said central processing means and said graphical processing means perform operations to render said scenes, without a pause between scenes, by performing the steps of:

- (a) rendering the next frame of the current scene;

(b) estimating a bandwidth availability for texture transfer that is unlikely to interfere with real-time rendering of the current scene;

(c) identifying the amount of data in a texture required for rendering a next scene;

5 (d) splitting said required texture into texture portions that satisfy said bandwidth availability; and

(e) transferring one of said texture portions from said data storage means to said texture storage means.

10 **12.** A method according to claim 11, wherein said estimating step (b) includes the steps of:

(b1) measuring a processing availability with reference to a due time for a frame in a regularly updated frame sequence;

15 (b2) updating an adaptive statistical model with said processing availability; and

(b3) obtaining an availability estimate from said updated adaptive statistical model.

20 **13.** A method according to claim 11, wherein said splitting step (d) includes splitting said texture along texture pixels.

14. A method according to claim 11, wherein said transferring step (e) is performed by a process of direct memory access.

25 **15.** A method according to claim 11, including deleting textures from said texture storage means.

16. A method according to claim **11**, wherein said central processing means performs the additional steps of:

(f) selecting a texture for deletion from said texture storage means; and

(g) deciding whether to delete said selected texture in response to an assessment of the time available before the next frame is due to be rendered.

17. A method according to claim **11**, including the further step of combining rendered animation images with images from a live video source.

18. A method according to claim **11**, including modifying a scene animation projection in response to camera position data.

19. A method of rendering animated image data in real time, in an image processing system comprising a central processing means, data storage means, graphical processing means, and texture storage means; wherein

said data storage means stores data including scene data, that defines a plurality of sequentially displayable scenes, each of which will be rendered as an image sequence in real time;

data for each of said scenes includes a texture for the respective scene, that is transferable to said texture storage means in advance of its rendering;

said central processing means and said graphical processing means perform operations to render said scenes, without a pause between scenes,

during which it is occasionally necessary to remove textures from said texture storage means in order facilitate sufficient texture storage for a next scene; and

said operations are under the control of said central processing means that executes instructions to perform the steps of:

- (a) rendering the next frame of the current scene;
- (b) identifying a time before the rendering for the next frame begins;
- (c) comparing said time identified at said identifying step (b) with the time required to delete a texture from said texture storage means; and
- (d) if it can be completed before the next frame rendering is due to begin, deleting a texture from said texture storage means.

20. A method according to claim **19**, including the additional step of:

- (e) downloading a texture into a portion of said texture storage means that has been emptied by said deleting step (d).

21. A computer-readable medium having computer-readable instructions executable by a computer such that, when executing said instructions, a computer will perform the steps of:

storing data including scene data that defines a plurality of sequentially displayable scenes to be rendered as an image sequence in real time;

data for each said scene includes a texture for the respective scene, that requires transfer to said texture to storage in advance of its rendering;

said rendering process comprising the steps of:

- (a) rendering the next frame of the current scene;
- (b) estimating a bandwidth availability for texture transfer that is unlikely to interfere with the real time rendering of the current scene;
- 5 (c) identifying the amount of data in a texture required for rendering a next scene;
- (d) splitting said required texture into texture portions that satisfy said bandwidth availability; and
- (e) transferring one of said texture portions to storage.

10 **22.** A computer-readable medium having computer-readable instructions according to claim **21** such that when executing said instructions a computer will also perform the steps of

- 15 (b1) measuring a processing availability with reference to a due time for a frame in a regularly updated frame sequence;
- (b2) updating an adaptive statistical model with said processing availability; and
- (b3) obtaining an availability estimate from said updated adaptive statistical model, as an implementation of said estimating step (b).

20 **23.** A computer-readable medium having computer-readable instructions according to claim **21** such that when executing said instructions a computer will also perform the step of splitting said texture along texture pixel, as part of said splitting step (d).

25 **24.** A computer-readable medium having computer-readable instructions according to claim **21** such that when executing said instructions

a computer will also perform the steps of:

(f) selecting a texture for deletion from said texture storage means; and

(g) deciding whether to delete said selected texture in response to the time before the next frame is due to be rendered.

25. A computer-readable medium having computer-readable instructions according to claim **21** such that when executing said instructions a computer will also perform the step of combining rendered animation images with images from a video source.

26. A computer-readable medium having computer-readable instructions according to claim **21** such that when executing said instructions a computer will also perform the step of modifying a scene animation projection in response to camera position data.